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Perceptions of Minimally Invasive Osteosynthesis: A 2018 Survey of Orthopedic Surgeons

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Abstract

Objective: To report perspectives of minimally invasive osteosynthesis techniques in veterinary surgical practice in 2018

Study design: Electronic questionnaires

Sample population: Diplomates and residents of the American & European Colleges of Veterinary Surgery (ACVS & ECVS) and members of the Veterinary Orthopedic Society (VOS)

Methods: Survey questions pertaining to minimally invasive osteosynthesis (MIO) and minimally invasive plate osteosynthesis (MIPO) were sent electronically to the sample population. Questions assessed training, current caseload, benefits and limitations of MIO and MIPO.

Results: Two hundred and fifty-six veterinary surgeons completed questions pertaining to MIO and 238 veterinary surgeons completed questions pertaining to MIPO. When considering MIO, only 16% of respondents reported that they performed MIO techniques regularly or exclusively and 62% wanted to perform more MIO than they were currently undertaking. Tibial fractures were most commonly selected for MIO/MIPO stabilization techniques in both cats and dogs. Challenges in achieving adequate fracture reduction was identified as the biggest limitation of MIO/MIPO techniques. Forty three percent of respondents felt there weren't enough MIPO training opportunities.

Conclusions: Currently MIO/MIPO techniques are performed infrequently with a large proportion of respondents revealing that they would like to perform more in the future. There is also evidence that further training opportunities would be welcomed when considering MIPO.

Clinical significance: Despite evidence of the benefits of MIO and MIPO over more traditional fracture stabilization approaches our survey has highlighted that significant barriers remain before the techniques are likely to be more widely adopted.

Introduction:

In recent years there has been a trend in both human and veterinary medicine away from anatomical reconstruction and rigid internal fixation towards more biological approaches to fracture fixation.[1-3] Minimally invasive osteosynthesis (MIO) techniques, are becoming widely accepted as alternatives to open reduction and internal fixation (ORIF) for the stabilization of fractures. By definition MIO includes any fracture fixation technique that involves small skin incisions and avoidance of the deeper surgical/ fracture site. An intermediate surgical approach known as an 'open but do not touch' (OBDNT) can be utilized which lies somewhere between MIO and ORIF.[3,4] The authors are not aware of any study focusing on the benefits/ limitations of an OBDNT approach over other methods. Numerous MIO techniques are reported in the veterinary literature for the treatment of long bone fractures including external skeletal fixation,[5-8] minimally invasive plate osteosynthesis (MIPO)[9-20] and interlocking nails.[4,21-24] MIO techniques have also been applied to articular fractures,[25] sacroiliac joint luxation stabilization [26,27] and central tarsal bone luxation stabilization.[28] Reported advantages of MIO/MIPO techniques in human and veterinary patients include reduced postoperative pain,[29] preservation of the fracture hematoma,[1,30] improved vascularization of the fracture site,[31-33] more rapid healing,[4,11,15,17,29,34,35] less wound complications [12,17,36] and faster return to normal function compared with open approaches.[29,36] Disadvantages reported include the technical difficulty of the learning process, longer operating times, [37] prolonged healing, [38] fracture malreduction [34] and radiation safety issues associated with intraoperative fluoroscopy.[37,39] With the conflicting evidence Kulkarni et al [36] advocated an individual approach to each fracture based on a cost/ benefit analysis.

Minimally invasive plate osteosynthesis was first described by Brunner and Weber in the early eighties.[40] It involves the closed and indirect reduction of fractures followed by the

application of a bone plate without making an extensive surgical approach to the fracture site. Typically, small skin incisions are created at either end of the fractured long bone. A plate is then inserted through one of the incisions and passed through an epiperiosteal tunnel which spans the fracture site. Screws are then applied in the proximal and distal ends of the plate.[18] Advancements in implant technologies, in particular the introduction of locking plates, increased availability of intraoperative imaging and evolution of indirect fracture reduction techniques has resulted in MIPO gaining popularity in human orthopedic surgery.

Despite the presence of multiple studies advocating and reporting the use of MIO and MIPO techniques in both the veterinary and human literature there still remains conflicting evidence about the direct benefits of these approaches over more traditional rigid internal fixation techniques.[11,15,19,37,41] The veterinary literature to date has focused on objective benefits but has not identified whether these techniques are widely performed by the veterinary orthopedic community. A recent study demonstrated that minimally invasive surgical techniques were widely used by American College of Veterinary Surgeons (ACVS) Diplomates and residents but this study did not specifically investigate the application of MIO/MIPO techniques.[42] There is a paucity of data with regards to current application, training opportunities, perceived benefits and limitations of MIO/MIPO and motivating factors for performing these techniques. The objective of our study was to assess the current perceptions and applications of MIO/MIPO techniques amongst a population of veterinary orthopedic surgeons.

Materials & Methods:

Two electronic surveys were created using an Online Survey tool (www.onlinesurveys.co.uk). Ethical approval for the study was granted by the Ethical committee at the University of Bristol (Application 60043).

A link to the initial survey was provided by electronic mail to all small animal European College of Veterinary Surgery (ECVS) Diplomates and residents containing questions pertaining to minimally invasive osteosynthesis (MIO). This was then followed by another link to a second survey pertaining to MIPO which was also sent by electronic mail to all small animal ECVS Diplomates and residents. Finally, a link to the amalgamated survey (consisting of questions from the first and second survey) was circulated to members of the Veterinary Orthopedic Society (VOS) via electronic mail and posted on the American College of Veterinary Surgery (ACVS) small animal surgical forum.

Survey feedback and assistance was provided on an individual basis by email correspondence. Responses were only included if the questions were complete and returned within a 14-week period between February & May 2018. A survey response percentage was calculated where possible for the individual populations. The amalgamated survey sent to the VOS and ACVS can be found in the supplementary information online (Appendix 1).

Statistical analysis:

Descriptive statistical analysis was performed and presented as both counts and percentages of survey respondents. Groups were broadly defined based on age (over or under 50 years of

age) and Diplomate status (Diplomates vs non-Diplomates). Chi-squared tests were used to evaluate if there were any relationships between the age or Diplomate status of the respondents and relevant respondent's answers. An alpha of ≤ 0.05 was used for tests.

Results:

Survey response

In total 171 surgeons responded to the first survey, 153 responded to the second survey and 85 responded to the amalgamated survey. Both the first and second survey were sent to the 619 small animal members of the ECVS which equates to a 27.6% and 24.7% response rate, respectively. The total number of people exposed to the survey when it was circulated to the ACVS online forum and VOS is unknown and so response rates could not be calculated for these populations.

Minimally invasive osteosynthesis

Of the 256 veterinary surgeons who completed the questions pertaining to minimally invasive osteosynthesis, 73% were male (n=187) and 27% female (n=61). Seventy three percent (n=187) of respondents were 31-50 years of age. The Diplomate status for this group of respondents is presented separately (Figure 1). The majority of respondents (97%, n=248) reported that fractures consisted between 0-50% of their surgical caseload. Forty-one respondents (16%) stated that they performed MIO procedures regularly or exclusively. One hundred and fifty-seven respondents (62%) reported that they wanted to perform more MIO techniques than they currently did.

The three most common canine fractures addressed by the respondents using MIO techniques were tibial diaphyseal (82%, n=211), radial diaphyseal (45%, n=116) & femoral diaphyseal (45%, n=91) fractures.

The most frequent perceived advantages identified for MIO were faster healing time (64%, n=164), less post-operative pain (48%, n=123) and faster return to function (44%, n=113). The most commonly reported perceived limitations of MIO techniques were challenges to obtaining adequate fracture reduction (62%, n=158), technical difficulty (47%, n=120), increased surgical time (38%, n=97) and radiation safety issues (36%, n=92). When asked which of these was the most significant perceived limitation challenges to obtaining fracture reduction and the requirement for new equipment (Figure 2) were the two most frequently chosen options.

Minimally invasive plate osteosynthesis

Two hundred and thirty-eight veterinary surgeons completed questions pertaining to MIPO. Seventy four percent were male (n=177) and 26% were female (n=61). Seventy two percent (n=171) of respondents were between 31 & 50 years of age. Fifty nine percent (n=140) of respondents worked in private referral practice and 31% (n=73) in academic centers. Seventy one percent of respondents (n=169) performed MIPO for fracture fixation rarely or occasionally. Eighteen percent of respondents (n=42) reported that they have never performed MIPO before. Sixty three percent of respondents (n=151) wanted to apply MIPO more frequently than they were at the current time. Fractures most commonly stabilized with MIPO in dogs were tibial fractures (77%, n=184) followed by radial fractures (47%, n=112). Fractures most commonly stabilized with MIPO in cats where tibial fractures (55%, n=133) followed by femoral fractures (24%, n=57). A higher proportion of respondents had never performed MIPO in cats compared with dogs (39% vs 15% respectively).

Respondents were asked to consider what surgical method they would elect to perform when stabilizing a non reconstructible, comminuted, mid diaphyseal fracture of the tibia, humerus, femur and radius in a 20 kg dog and 5 kg cat. The responses for preferred stabilization method for each scenario are shown separately (Figures 3 and 4). When considering MIPO training 40% (n=95) of respondents stated that they had taught themselves MIPO techniques and 40% (n=95) reported that they had received specific MIPO training during their residency. Forty three percent (n=104) of surgeons felt that there were not enough training opportunities available for MIPO techniques. Forty two percent (n=101) of respondents indicated that they had never used fluoroscopy when performing MIPO.

The four most common perceived limitations to performing MIPO were challenges to obtaining fracture reduction (25%, n=60), requirement for new equipment (16% n=38), lack of training opportunity (14% n=33) and lack of proven benefit and/or efficacy (12%, n=28).

Statistical analysis

An association ($\chi^2 = 9.573$, df = 3, $p = 0.02$) was found between Diplomate status and the response to how much MIO the respondent would like to perform when compared with their current level (Table 1), with non-Diplomates being more likely to want to perform more MIO techniques than their current level.

A similar relationship was found between Diplomate status and responses to the questions regarding how much MIPO the respondent would like to perform when compared with their current level ($\chi^2 = 16.255$, df = 3, $p \leq 0.001$) and whether they felt there were enough training

opportunities for MIPO ($\chi^2 = 19.157$, df = 3, $p \leq 0.001$) (Tables 2 & 3). Non-Diplomates were more likely to want to perform more MIPO than they currently did and they were more likely to report that there are inadequate MIPO training opportunities.

Relationships were found between age of the respondent and responses to the questions regarding how much MIPO the respondent would like to perform when compared to their current level ($\chi^2 = 9.205$, df = 3, $p = 0.023$) and whether they felt there were enough training opportunities for MIPO ($\chi^2 = 9.065$, df = 3, $p = 0.032$) (Table 4 and 5). Younger respondents were more likely to want to perform more MIPO than they currently did and stated that there are not enough MIPO training opportunities.

Discussion:

To the best of the authors' knowledge this is the first survey assessing the current perspectives of MIO and MIPO in the veterinary literature. A large proportion of respondents (62%) highlighted that they wanted to perform more MIO and MIPO techniques than they were currently doing. This suggests that a considerable proportion of respondents perceive significant benefits of MIO and MIPO over more traditional approaches but for undisclosed reasons were not currently performing these methods. The survey has however identified that there are barriers to performing MIO and MIPO in veterinary orthopedic practice. This appears to be in contrast to other minimally invasive surgeries such as laparoscopy or thoracoscopy which were reported to be more commonly performed than the MIO/MIPO techniques in our study.[42]

Results of the survey demonstrate that within the population of respondents MIPO was not being performed as commonly in feline patients when compared with dogs. The reason for this difference is currently unknown as respondents were not specifically asked to comment. Potential explanations would include a relatively lowercase load for feline fractures in practice, or the smaller patient size which may be associated with a greater number of technical difficulties when performing MIPO in these patients.

In both cats and dogs, tibial fractures were reported to be the most commonly chosen long-bone fracture to be stabilized with a MIPO approach. This is likely to be associated with the relative ease of reduction of fractures of the tibia and the absence of significant soft tissue when compared with other bones, but this was not specifically investigated in the survey. When asked how respondents would approach non-reconstructible, comminuted, mid

diaphyseal fractures in different bones in a 20kg dog and a 5kg cat, the most frequently chosen answer was an ‘open but do not touch approach with a plate and intramedullary (IM) pin’, with the exception of the radius where an IM pin cannot be safely placed without damaging the joints either side of the fracture. This suggests that many respondents recognize the benefits of a more biological approach to fracture stabilization, including minimising surgical trauma and preservation of the fracture haematoma over more traditional open approaches. That said, in the authors experience, there is a very wide margin of interpretation of exactly what pertains to an open but do not touch approach [3] and limited objectivity of this technique in the literature. Further studies are required to investigate if there are any significant differences between fracture healing and outcome when comparing an ‘open but do not approach’ and MIPO.

Non-Diplomates were more likely to want to perform more MIPO and MIO when compared with their current level. This may reflect that MIO and specifically MIPO techniques are challenging and require a steeper learning curve which may be perceived to be too complex by inexperienced surgeons at the start of their career. Younger respondents were also more likely to want to perform more MIPO than their current level which again may support the theory that MIPO techniques are more technically challenging than open approaches, but the benefits are acknowledged. These differences may also be explained by the fact that there is more evidence supporting MIPO and MIO approaches in the recent literature which may encourage respondents who are currently training to perceive the benefits but due to the steep learning curve are reluctant to perform MIPO procedures.

Our study highlights that the most significant perceived limitations when performing MIPO were challenges when attempting fracture reduction, requirement for new equipment and a lack of proven benefit/ efficacy. The perceived limitations of MIO were similar to those for MIPO with challenges when attempting fracture reduction being the most commonly cited. Numerous techniques have been described to aid with fracture reduction including basic external skeletal fixators, distraction devices, plate fixation itself and other instruments such pointed reduction forceps.[11,14,43,44] A novel approach has recently been reported with the use of a 3D printed patient specific guide for repair of a comminuted humeral fracture in a cat [13] which is an area with considerable potential for use in these cases. In certain situations, expensive additional equipment is not always required. In a study by Schmokel et al [16] no specific additional equipment was required in seven dogs with tibial fractures stabilized with MIPO in which the application of a pre contoured plate was the sole device used in these cases. Further studies are required to ascertain whether the degree of fracture alignment is related with a detrimental outcome or not.

Interestingly, in our study, 50% of respondents either rarely or never used fluoroscopy when attempting MIPO techniques. This may be a potential explanation as to why challenges to adequate fracture reduction was listed as the most important perceived limitation to MIO & MIPO. Previous studies have recommended the use of intraoperative fluoroscopy to improve fracture alignment but suggest that the benefits should be weighed against the risks of performing fluoroscopy.[11,19,39,45] Currently, to the authors' knowledge, there are no specific studies evaluating whether there is a significant benefit of intraoperative fluoroscopy in fracture alignment when performing MIPO.

There are clear advantages and disadvantages for minimally invasive approaches to fracture stabilization when compared with open approaches. That said, the human and veterinary literature is not clear and often conflicting with regards to developing a cost benefit analysis for these cases. For example, there is some evidence that operating times were not statistically different when comparing MIPO and more traditional techniques in one metanalysis by Yu et al.[41] However, another metanalysis by Li et al [37] showed that minimally invasive approaches were associated with longer operating times. Nine percent of respondents of our survey perceived that longer operating times was the most significant perceived limitation to performing MIPO over a more traditional approach. One study in the human literature [36] did show that the operating time was largely dependent on surgeon skill and experience. The authors of this latter study concluded that an individual specific approach should be used in each case despite the benefits shown with a MIPO approach over an interlocking nail or open approach and rigid internal fixation.[36] Until clear evidence can be provided that one approach is significantly more effective than another the authors would suggest that a decision is based on a case by case basis. Further randomized controlled trials are required before further conclusions can be made.

Both younger respondents and non-Diplomates were more likely to respond negatively when asked if there were sufficient training opportunities for MIPO techniques. This mismatch suggests that there is feeling amongst younger surgeons that more training opportunities in MIPO would be beneficial. The ACVS have included a minimum number of minimally invasive surgeries in their residency training programs to try to increase the exposure of surgeons in training to these techniques.[42] There is scope for this to be adopted into other residency training programs to try to address this perceived lack of training opportunities as well as the development of MIPO specific training courses.

Interestingly, multiple respondents highlighted that there was confusion in the literature as to the exact definition of what techniques constituted MIO and MIPO. There is a danger as new techniques continue to be developed that this situation only becomes more confusing and highlights the potential need for a consensus to be developed.

Limitations:

By nature of the design there are limitations to this survey. Whilst this study attempted to ascertain the perspectives of MIO and MIPO in veterinary practice the survey was only circulated amongst a specific subpopulation of veterinary surgeons, namely ECVS and ACVS Diplomates and residents and VOS members and only a proportion of these responded. The response rate was similar to a previous survey conducted on minimally invasive surgery perceptions. This potentially introduces an element of bias to the study. For example, individuals who may have a specific interest in the topic would probably be more likely to complete the survey compared to individuals who have no incentive, interest or requirement to complete the survey. As with all survey-based studies there is likely to exist bias between responders and non-responders, and between our target population and veterinary surgeons as a whole.

A further limitation of our study was in the design of the questionnaires. It would have been more prudent to simply create one survey that was circulated to every member of the study population.

Conclusion:

Despite evidence of the benefits of MIO and MIPO over more traditional fracture stabilization approaches, controversy still remains as to whether these techniques are superior to open reduction and rigid internal fixation. Further prospective studies are needed to clarify this position. Our survey has highlighted that significant barriers remain before the technique is likely to be more widely adopted. There is also evidence that further training opportunities would be welcomed when considering MIO and MIPO techniques. Currently MIO/MIPO techniques are performed infrequently with most respondents revealing that they would like to perform more in the future.

Disclosure:

The authors declare no conflict of interest to this report.

Table 1: Diplomate status vs responses to the question "How much MIO would you like to perform compared with your current level?"

		Less	The same	More	Exclusively	Total
Diplomate	Count	3	82	113	1	199
		2%	**41%**	**57%**	**1%**	
Non-Diplomate	Count	0	12	45	0	57
		0%	**21%**	**79%**	**0%**	

Table 2: Diplomate status vs responses to the question "How much MIPO would you like to perform when compared with your current level?"

		Less	The same	More	Exclusively	Total
Diplomate	Count	2	73	102	1	178
		1%	**41%**	**57%**	**1%**	
Non-Diplomate	Count	2	8	49	1	60
		3%	**13%**	**82%**	**2%**	

Table 3: Diplomate status vs responses to the question "Do you feel there are sufficient training opportunities for the technique of MIPO?"

		Yes	No	No opinion	Other	Total
Diplomate	Count	47	65	65	1	178
		26.4%	**36.5%**	**36.5%**	**0.6%**	
Non-Diplomate	Count	9	39	10	2	60
		15%	**65%**	**17%**	**3%**	

Table 4: Age vs responses to the question "How much MIPO would you like to perform when compared with your current level?"

		Less	The same	More	Exclusively	Total
21-50	Count	2	54	124	1	181
		1.1%	**29.8%**	**68.5%**	**0.6%**	
51-71+	Count	2	27	27	1	57
		4%	**47%**	**47%**	**2%**	

Table 5: Age vs responses to the question "Do you feel there are sufficient training opportunities for the technique of MIPO?"

		Yes	No	No opinion	Other	Total
21-50	Count	39	88	51	3	181
		21.5%	**48.6%**	**28.2%**	**1.7%**	
51-71+	Count	17	16	24	0	57
		30%	**28%**	**42%**	**0%**	

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